Report of the Regional Science Topic Workshop on Remote Sensing and Landscape Characterization

November 1 – 3, 2005
Chicago, Illinois

ORD REGION

RESEARCH AND DEVELOPMENT

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

SUBJECT: Region/ORD Remote Sensing/Landscape Characterization Workshop

FROM: George Gray
Assistant Administrator (8101R)

TO: All Workshop Participants

Thank you for your participation in the *Region/ORD Remote Sensing/Landscape Characterization Workshop* held November 1-3, 2005, at the Region 5 office in Chicago. Attached is the final workshop report, which summarizes the workshop presentations and discussions.

This ORD-sponsored workshop was jointly planned and implemented by staff from EPA Regions 4 and 5, the Office of Research and Development, and the Office of Environmental Information. The major objectives of the workshop were to provide participants with a better understanding of the science and scientific applications relevant to remote sensing and landscape characterization and establish a network of EPA scientists who, after the workshop, will continue to exchange information and work together on this science. This training workshop addressed: 1) how remote sensing technologies are applicable to environmental work; 2) how remote sensing technologies integrate with land-based data to assist Regions, States, Tribes, and local communities in landscape characterization for environmental purposes; 3) how to access remote sensing technologies, both inside and outside of EPA; and 4) how remote sensing relates to the Global Earth Observation System of Systems.

For additional information on this workshop, please contact David Macarus, Region 5 Science Liaison, at (312) 353-5814 or Tom Baugh, Region 4 Science Liaison, at (404) 562-8275. Contact Dick Garnas, Office of Science Policy/ORD, at (202) 564-6785 for information on other workshops in the Region/ORD Science Topic Workshop Series.

Attachment

cc: Deputy Regional Administrators
ORD Executive Council
Regional Science Liaisons to ORD

U.S. Environmental Protection Agency
Office of Science Policy
Regional Science Workshop on Remote Sensing and Landscape Characterization

U.S. EPA Region 5
Lake Michigan Room, 12th Floor
Valdas V. Adamkus Environmental Resource Center
77 W Jackson Boulevard
Chicago, IL 60604

November 1-3, 2005
MEETING SUMMARY

<u>November 1, 2005</u>

Welcome to the Workshop

Mr. Bharat Mathur, Deputy Regional Administrator, U.S. Environmental Protection Agency (EPA) Region 5, welcomed the participants to Chicago and to the Regional Science Workshop on Remote Sensing and Landscape Characterization. He explained that the general goal of Region 5 workshops is to provide scientists with the tools to address topics such as emerging pollutants, pesticide exposures, endocrine disruptors, and so forth. One goal of this workshop is to develop a network of Regional scientists to collaborate and share ideas on remote sensing and landscape characterization to further the topic.

Dr. David Klauder, from EPA's Office of Research and Development's (ORD) Office of Science Policy (OSP), welcomed participants to the meeting and explained that OSP sponsors and co-hosts the Regional workshops with the Regions. He introduced Dr. Gary Foley, Director of EPA's National Center for Environmental Research via video.

Dr. Foley explained that ORD, with nearly 2,000 employees, 14 laboratory and research facilities, and a $55 million external grant budget, is tasked with providing credible, relevant, and timely research results and technical support to inform EPA policy decisions. Making decisions with sound science requires relevant and high-quality research that is properly characterized and appropriately used in the decisionmaking process. EPA's high-priority research areas include human health, particulate matter, drinking water, global change, endocrine disruptors, homeland security, and many others. The general goals of the Regional workshops are to create cross-Agency science networks and collaborations, identify opportunities to integrate EPA's science into Regional decisionmaking, and identify the most critical science uncertainties. Topics of the workshops are identified by the Regions and anticipate future environmental issues. Remote sensing and landscape characterization was identified as a topic because it offers new tools to enhance the ability to monitor environmental changes and better focus on remediation strategies.

Dr. David Macarus, the Planning Committee Chair from EPA Region 5 Office of Science, Ecosystems, and Communities, thanked the collaborators of the meeting, including Thomas Baugh, Steve Goranson, John Lyon, Ed Washburn, Ross Lunetta, and all of the speakers. He introduced Stephen Goranson, the moderator for the afternoon session.

Stephen Goranson, Chief of the Information Services Branch at EPA Region 5, explained that the specific workshop objectives were to discuss current and planned projects using remote sensing and landscape characterization information and to identify real possibilities for collaborative projects on the gathering and application of remote sensing and landscape characterization information.

November 1, 2005, Afternoon Session

Moderator: Steve Goranson, EPA Region 5, Office of Information Systems

Remote Sensing Overview: EPA Capabilities, Priority Agency Applications, Sensor/Aircraft Capabilities, Cost Considerations, Spectral and Spatial Resolutions, and Temporal Considerations

Ross Lunetta, U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory, Environmental Science Division, Research Triangle Park, NC

Within the Environmental Science Division (ESD) of EPA's National Exposure Research Laboratory (NERL), there are two main branches that provide remote sensing support, the Landscape Ecology Branch and the Landscape Characterization Branch. Data costs for remote sensing vary widely from no cost to being cost prohibitive. U.S. government satellite data and archive aerial photography are available for a nominal data reproduction and distribution charge, which is applied for both Landsat imagery and archive aerial photography. Data costs generally increase proportionally with the increased spatial resolution (geometric); aircraft data are approximately one order of magnitude more expensive than that collected from satellite platforms, whereas commercial satellite imagery is approximately one order of magnitude more costly than that acquired from U.S. government assets. In planning for a remote sensing project budget, a guideline to follow is that data acquisition will account for 15 percent of the budget, data processing for 50 percent, and accuracy assessment for 35 percent. General data types for remote sensing include aerial photography, multispectral imagery, and light detection and ranging (LIDAR); radar and microwave data are rare. In formulating a remote sensing project, it is important to articulate the information (data) needs required in as much detail as possible and to formulate the data quality objectives required for specific data needs. The three basic principals of remote sensing that are relevant to this workshop are thematic, spatial, and temporal resolutions.

Currently available satellites are able to provide increased spatial resolution, which provides increased landscape patchiness, or increased temporal resolution, which provides increased biodiversity information; however, no satellite currently exists that can provide both spatial and temporal resolutions at high levels. Remote sensing can be used for water quality applications (e.g., mapping submerged aquatic vegetation beds, monitoring turbidity plumes, real-time measurement of water quality parameters, etc.); landscape (terrestrial) applications (e.g., wetland mapping); and atmospheric monitoring applications (e.g., impact of smoke on regional air quality, determination of ammonium emission, detection of particulate matter exposure). In performing accuracy assessment of the gathered data, it is important to consider three quality principals: radiometric quality, geometric quality, and thematic quality. After data are collected, an accuracy assessment is performed to determine the source of any errors by comparing the remote sensing data to reference data (e.g., field measurement data, interpreted aerial photography, and other remote sensing-derived data). The current trends in remote sensing include: (1) application of high-frequency remote sensor data collections to support multitemporal data analysis; (2) development of a multistage approach that uses coarser resolution (high frequency) data for complete area coverage supplemented with higher resolution data for identified areas of interest; (3) integration of *in situ* monitoring networks with remote sensor data to extend the spatial distribution of field monitoring observations; and (4) use of unmanned aerial vehicles with integrated sensor packages for both multistage data collections and "telaplace" monitoring capabilities.

National Land Cover Database

James Wickham, U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory, Environmental Science Division, Research Triangle Park, NC

The original 1992 National Land Cover Database (NLCD) was a bilateral initiative between ORD and the Earth Resources Observation and Science (commonly known as EROS) Data Center. The Multi-Resolution Land Characteristics (MRLC) Consortium is a group of Federal agencies that formed as a consortium to acquire remote sensing data for environmental monitoring. Currently, the consortium includes EPA, the U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Agriculture (USDA), U.S. Forest Service, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service (USFWS), and National Aeronautics and Space Administration (NASA). For the project, the continental United States is divided into 66 mapping quadrants, and the metadata of the 2001 NLCD consists of image data (collected in the spring, summer, and fall), ancillary digital elevation model (DEM) data, impervious surface and tree canopy derivatives, and land cover data. The three primary components of the 2001 NLCD are land cover (both native pixel and a convolved 4-pixel product), impervious surface, and canopy density and are supported by a node map, a confidence map, and decision rules for node map interpretation. The impervious surface component is an estimated percentage based on an extrapolation from the digital ortho quarter quads, resulting in a crisper map when compared to the 1992 NLCD. The node map component is derived from regression tree software, and each "terminal node" or "leaf" is assigned a number that can be used with an associated text file to trace the history of classification. The confidence map is derived from the regression tree in 1 percent increments with two different patterns of significance.

Currently, land cover, impervious surface, and canopy density data are available for various regions of the United States. The 2001 data are freely available from the MRLC Consortium Web Site at http://www.mrlc.gov/. In comparing the 1992 data with the 2001 data, however, a pixel-to-pixel comparison is not possible because data are not in the same geometric space (i.e., 90-m DEM in 1992 vs. 30-m DEM in 2001), different classification methodologies were used, and slight changes in class definitions occurred. The approach to compare the two and generate land cover change data that is low cost, operationally fast, rigorous, robust, and applicable nationwide is to: (1) compare NLCD1992 and NLCD 2001 at Anderson Level 1 to establish areas of agreement; (2) use these areas of agreement as the source of training pixels to develop a decision-tree classification of the 1992 image mosaic, as well as the 2001 image mosaic; and (3) use confidence data, spatial information, and spectral data to generate Anderson Level 1 classifications that identify areas of probable change. To request land cover change imagery, send an e-mail to esrisupport@epa.gov and provide the tar file name(s) from the MRLC Web Site (http://www.mrlc.gov/download_data.asp) or provide path/row and date. The staff then will arrange the best method of data transfer. Currently, NLCD data are being used in a project to address impaired water sites in Illinois and their likelihood of recovery.

National Wetland Inventory and Remote Sensing Applications in Wetlands Evaluation

Brian Huberty, U.S. Fish and Wildlife Service, Ft. Snelling, MN

The National Wetland Inventory (NWI) is an environmental indicator tool that can identify the status and trends of U.S. wetlands and also serves as a resource management tool, providing a standard wetland/surface water map of the United States. The NWI is important for resource management, water purification, fish and wildlife habitat identification and protection, flood prevention, erosion control, recreation, biological productivity, and water supply protection. Previously, the national status of wetlands was determined every 10 years but now is determined every 5 years. Although the rate of wetland loss over time has declined, this is a result of an increase in backyard ponds; actually, natural wetlands are decreasing. Currently, NWI is correcting and updating features of wetland maps with digital orthoimages. NWI is also creating a Master GeoDatabase (MGD), one of the top three largest civilian, topologically structured datasets in the world. The MGD is a seamless, standardized dataset that allows state and public access via a Web site.

Informational goals (e.g., spatial, spectral, or temporal) determine what resolution is necessary for data interpretation and identification. Another key component of information needs is positional accuracy. The Landsat satellite program most likely is approaching its end, but the USDA's National Agriculture Imagery Program, which acquires aerial imagery during growing seasons, makes its digital ortho photography images available. Four major vendors are sources for remote sensing equipment: (1) Airborne Data Systems, Inc.; (2) Leica Geosystems; (4) Intergraph Corporation (Z/I DMC® Digital Mapping Camera); and (4) Vexcel (UltraCam™ Digital Aerial Camera). Another tool for remote sensing is LIDAR, which uses lasers to emit light pulses that strike the ground and reflect back to the airborne sensor. Because the precise altitude and position of the sensing aircraft is known, the elevation of surface points can be determined based on the amount of time it takes for the pulse to return to the sensor. Interferometric Synthetic Aperture Radar (known as IFSAR) is another tool to determine elevation information. Currently, there are no comprehensive and current (statistical or mapped) estimates or comprehensive and synoptic high-resolution images of the Great Lakes Basin wetlands. This is significant because the Great Lakes account for 20 percent of the Earth's and 95 percent of North America's surface freshwater. Geospatial infrastructure, in addition to additional satellites, airborne data, and geospatial information, is needed for future remote sensing applications.

An upcoming event that may be of interest is the American Society for Photogrammetry and Remote Sensing's Great Lakes Conference to be held October 28-November 1, 2007, in Ottawa, Canada. Additionally, Dr. Huberty will be resurrecting the wetland remote sensing component of the Federal Geographic Data Guidelines and asked participants to contact him if they were interested in this area.

Activities in Great Lakes Landscape Characterization and Urban Energy Use Sustainability

Bert Guindon, Canada Centre for Remote Sensing, Ottawa, Ontario, Canada

In the early 1990s, the Canada Centre for Remote Sensing (CCRS) and EPA compared expertise in image processing, archival imagery, systems design and development, landscape ecology, water quality assessment, and available datasets and determined that a collaboration between the two involving land cover mapping of the Great Lakes watershed would be synergistic. From this collaboration, the Composite Land Processing System (CoLaPS) was developed to merge together the multitude of composite archival Landsat scenes from 1972-1992. CoLaPS does not take a traditional approach of mosaicing images together to merge the scenes but instead composites land cover classifications. Additionally, it provides a seamless linkage between its land cover production system and user subsystem. CoLaPS offers the ability to study subareas (e.g., subwatersheds) and perform riparian analysis. The system was used for forest fragmentation analysis in the Great Lakes sub-basins using an algorithm that compared the relationship of ratios of forest pixels surrounded by other forest pixels and then linking it to deforestation models to determine how sensitive the fragmentation characteristics were to deforestation strategies. These models also can be used to forecast deforestation in developing countries.

Another project of CCRS, mandated by the Canadian government, is to utilize remotely sensed land use and land cover information and determine how it impacts energy consumption. The federal priorities for this project include urban agenda development, transportation-related energy consumption, environment issues, climate change, and land use pressures. One-quarter of Canada's greenhouse gas emissions come from transportation, two-thirds of which come from urban areas. The strategy to forge science-policy links to manage the energy priorities included providing a historical perspective and also relevant geospatial information (i.e., the Canadian Urban Land Use Survey, which integrates land cover/land use information derived from Landsat images with census information), methods for indicator quantification (e.g., urban compactness and the transport mode index), a survey of geospatial aspects of work-related travel (i.e., the archetypal Canadian urban form), travel prediction models to support forecasting, and direct access to geospatial information for policymakers. The ultimate goal of the project is to develop forecasting capabilities that can be given to policymakers to predict energy consumption.

November 2, 2005, Morning Session

Moderator: Pranas Pranckevicius, EPA Region 5, Great Lakes National Program Office

Using Remote Sensing, GIS, and Field-Based Techniques To Assess Ecological Conditions in the Great Lakes Basin

Ric Lopez, U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory, Environmental Science Division, Las Vegas, NV

The practical applications of remote sensing, geographic information systems (GIS), and field techniques are being used to map wetlands and analyze ecological and watershed condition metrics in the Great Lakes Basin and also to create new maps and improve the ecological functions (e.g., attenuating floods, improving water quality, and increasing biological diversity/wildlife habitat) of palustrine wetlands of the Gulf Coast Region. The Landscape Ecology Approach is an ecological approach at a broad scale. In using this approach, the Landscape Ecology Branch of ESD produces land cover datasets, examines changes in land use or cover (i.e., potential "drivers" of ecological change), and then determines changes in landscape composition and pattern over time and space (e.g., forest fragmentation). These changes are then linked with potential changes in ecological processes (i.e., "receptors") that affect terrestrial species. These changes may cause changes in ecological goods and services, which in turn may drive policymaking decisions. Performing the landscape ecology assessment of the Great Lakes Basin using this approach presented challenges, such as mapping land cover for a vast area (i.e., drivers), calibrating geospatial data with field information, and mapping land cover metrics that have potential as indicators of ecological condition (i.e., receptors). The summary dataset from the assessment is available to the Great Lakes research community in the Landscape Ecology Metric Browser (v2.0) and includes information about general landscape characteristics, sediment flowing to coastal wetlands, sediment available for coastal nourishment, urban density, land conversion, habitat adjacent to coastal wetlands, and habitat fragmentation, which are linked with State of the Lakes Ecosystem Conference (SOLEC) indicators. The initial landscape metrics findings indicate that increased wetland edge and wetland density are associated with reduced plant community biodiversity.

The landscape ecology approach also was used to assess the ecological functions of depressional wetlands in the Gulf Coast Region. Depressional wetlands were chosen because they: (1) have similar functions to other wetlands; (2) are individually small and diffuse but cumulatively include a tremendous amount of wetland; (3) are easier to identify because there is consensus on their size, shape, location, position, and proximity; and (4) may be "isolated" in the landscape, leading to questions of how they function. Data gathered about the depressed wetlands can be extrapolated to larger watersheds (e.g., the Great Lakes Basin). Multiseason/multiyear data representative of the region from 1999-2003 was used in a regression analysis. Photogrammetric accuracy assessment was done to determine if the technique was comparable in accuracy to NWI, NLCD, and Gap Analysis Program (GAP) vegetation association datasets. The GAP vegetation association dataset, however, was not useful for identifying depressional wetlands in coastal Texas. The ultimate goal of the project is to produce a map product for the Region with the relative accuracy with respect to the NLCD and NWI datasets.

The Great Lakes Observing System (GLOS) Remote Sensing Subsystem Plan

Roger Gauthier, Great Lakes Commission, Ann Arbor, MI

The Global Earth Observing System of Systems (GEOSS), coordinated by the United Nations and the World Meteorological Organization, developed from an international desire to develop a framework of interoperability between and within nations to share information about the environment at large. Additionally, a Commission on Oceans Policy report called for a major investment in the Great Lakes, oceans, and coastal areas. As a result, NOAA led legislative activities to form the Integrated Oceans Observing System (IOOS). The objectives of IOOS are to: (1) facilitate safe and efficient maritime operations; (2) mitigate the effects of natural hazards; (3) improve prediction of climate variability; (4) reduce public health risks; (5) improve national security; (6) sustain and restore living resources; and (7) preserve and restore healthy ecosystems. The IOOS approach is focused on defining research needs and developing pilot activities for preoperational projects to create operational functionality with a linkage at the local, regional, and global levels. Eleven regional associations are being developed to support IOOS, many of which are led by academic institutions. The Great Lakes Commission, with Federal support, is coordinating the Great Lakes Observing System (GLOS), one of the 11 regional nodes of IOOS. GLOS supports 13 user communities and focal areas, including the important areas of safe drinking water and commercial navigation.

A draft strategic business plan for GLOS was completed, and a regional data management and communications (DMAC) node currently is being developed. Additionally, a pilot data integration project is being developed for the St. Clair and Detroit rivers and the Lake St. Clair system. GLOS is focusing on integrated data collection, analyses, modeling, and value-added product creation for a series of meteorologic, hydrologic, hydraulic, chemical, and biological themes. The remote sensing subsystem focal areas are lake-wide process monitoring, regional land cover assessments, high-resolution land use changes, coastal wetlands monitoring, and emergency response products. Additionally, nearshore observations of wind, waves, water levels, water chemistry, sediment, nutrient, and contaminant loading to the system are important. The nearshore subsystem components include water level observation system improvements, vertical control network improvements, directional wave metering, high-frequency radar deployment, airborne LIDAR and hyperspectral mapping, tributary streamflow station upgrades, and sediment transport modeling. Components of the interconnecting waterway subsystem are permanent flow metering, Lake St. Clair buoy deployment, hydrodynamic modeling, and field calibration. The hydrodynamic modeling subsystem includes modeling improvements, data assimilation and analysis, and operational product delivery. The information integration subsystem, a major focus of the project, includes a regional DMAC clearinghouse node, Web partnerships, linkage to the Great Lakes Information Network, and national DMAC interfaces. The regional emphasis for remote sensing is to implement a coastal remote sensing program, conduct periodic technical workshops, and initiate focused education and outreach.

The Great Lakes Interagency Task Force draft plan calls for a $20 billion investment to restore ecological balance to the system and is focused on supporting the U.S. contribution to GEOSS through IOOS/GLOS and the Integrated Earth Observing System (IEOS), enhancing the coordination of monitoring activities, implementing high-value SOLEC indicators, establishing a regional information management infrastructure, creating a Great Lakes communications workgroup, and increasing funding for Great Lakes research. Two critical near-term actions will be to enhance the physical and chemical observations in the Lake Huron to Erie corridor through implementation of GLOS and convene information managers under the Regional Data Exchange Initiative to develop inventories of data resources and initiate Web-based integration among agencies.

The Midwest Spatial Decision Support System Partnership Update With Emphasis on Remote Sensing/Landscape Characterization and Rural to Urban: Using NASS Cropland Data Layers To Estimate Changes

Richard Farnsworth, Purdue University, West Lafayette, IN

In Dr. Bartholic's unexpected absence, Dr. Farnsworth presented information from both presentations as part of an update on the Midwest Watershed Decisions Support Systems Partnership (MWDSSP).

At the April 2002 Midwest Web-Based Spatial Workshop in Chicago, Illinois, a group of organizations and universities formed the MWDSSP to develop decision support tools and systems for decisionmakers, including watershed planning groups, public officials, and development and planning groups in government and the private sector, to assist them in developing and implementing economically viable, ecologically sound plans. The specific objectives are to: (1) develop, promote, and use Web-based, user-friendly, geospatial watershed management data and decision support tools; and (2) help set the standard for other watershed management programs, such as promoting data initiatives, relating specific tools to planning process phases and learning objectives, and creating systems where outputs of tools can be plugged into other models. The tools developed for local officials, natural resources managers, and the general public are Web-based, spatially based and scalable, science-based, accessible in the public domain, intuitive, customizable, and freestanding.

In 2002, Michigan State University was working on a digital watershed project, a nationwide Web application tool for effective watershed management, and Purdue University was working on long-term hydrologic impact analysis model simulations for watersheds. A partnership formed with the goal of making the digital watershed available to various stakeholders and the public. To meet that goal, the digital watershed must be an information repository that has nationwide watershed coverage, multiple forms of access, comprehensive datasets, a scaling function, online environmental modeling, and online erosion and deposition modeling. The digital watershed provides enhanced usefulness of the Great Lakes Basin landscape ecology metric. Additionally, another goal of the MWDSSP is to utilize LandSat for sprawl assessment to facilitate wise land use decisionmaking. To this end, overlay methods are used in wide-area landscape analysis to combine different datasets to help local decisionmakers in zoning and other development determinations. MWDSSP also has enhanced the usability and functionality of EPA's STORET database, which also is important for communities trying to make decisions.

Dr. Farnsworth concluded the MWDSSP presentation and began his presentation on using the National Agricultural Statistics Service's (NASS) cropland data layers to estimate change.

The challenge was to address the loss of agricultural and forest lands to urbanization, but existing estimates of land use changes were based on random samples and only valid across the state. A previous GIS project (i.e., the Indiana University-Purdue University Indianapolis [IUPUI] land use map) was useful but too time-intensive and costly to repeat. Therefore, the project objectives were to: (1) use past land cover spatial data and existing remotely sensed data (e.g., the IUPUI land use map and the USDA's NASS cropland data layers from 2000-2003) to estimate land use change; (2) use ModelBuilder to document the analysis; and (3) summarize the conclusions and make appropriate recommendations. The advantages of using the NASS data was that it provided yearly data for 4 years and beyond, contained major land use categories as part of the map layers, and offered high accuracy for major agricultural crops. Some disadvantages included the presence of considerable variation across years in land cover as well as the fact that pasture/rangeland is considered a "catchall" category, distributed throughout urban and rural areas, and comprised approximately 30 percent of each year's data. The solution was to apply rules to fill in missing data and remove cloud cover, use all available data (e.g., the IUPUI map layer and NASS data) to create a base 2000 land cover map with a focus on urban areas, and rely extensively on the neighborhood analysis tool to reduce speckling and reclassify pixels in all categories. Following this process, data were analyzed and it was determined that part of the urban growth in Indiana between 2000 and 2003 is capturing earlier urban growth and areas that were misclassified as pasture/rangeland. The conclusions of the project were that: (1) NASS data layers contain valuable information, especially when combined with other spatial data. (2) Incorporating new NASS layers and repeating the analysis will begin to capture new growth. (3) ModelBuilder provides a cost-effective framework for incorporating new data and running the analysis yearly. (4) The addition of other spatial data layers will improve model results.

Did the May 2004 Milwaukee Sewer Overflows Affect Chicago Beaches?

David Rockwell, Great Lakes National Program Office, Chicago, IL

Initial reports from the Milwaukee Metropolitan Sewerage District indicated that heavy rains during the month of May 2004 resulted in more than 4 billion gallons of storm and sewage overflows in Milwaukee, Wisconsin. The estimated amount of the sewer overflows was later revised to 1.2 billion gallons. The deep tunnel systems that Milwaukee utilized were overwhelmed by the amount of rainfall received and the excess overflow entered Lake Michigan. Chicago beaches were temporarily closed in June 2004 because of high *Escherichia coli* levels in the water and the Milwaukee sewage overflow events were blamed. EPA was mandated to examine the potential impact of the Milwaukee discharge on Chicago beaches.

To accomplish this, hourly wind records were gathered from surface weather stations around Lake Michigan for the period of May 1-June 20, 2004; station observations were interpolated to create continuous wind fields over the entire lake. The wind fields then were used to drive a lake circulation model, which was calibrated and validated using the Lake Michigan Mass Balance datasets of 1994 and 1995. Currents from the lake circulation model were used to track the movement of water originating from Milwaukee Harbor as it moved into southern Lake Michigan toward Chicago. Additionally, extensive E. coli samples were collected between May 14–May 19, 2004, in Milwaukee Harbor. The highest concentrations were in the river water plume inside the harbor and within 1 km or the harbor breakwall. As determined by conductivity measurements, concentrations dropped sharply outside of the river water plume. Sampling surveys on subsequent days consistently demonstrated less than 200 *E. coli* per 100 mL at distances 2-5 km from the harbor breakwall and less than 20 *E. coli* per 100 mL at distances greater than 5 km from the harbor. The lake circulation model, *E. coli* sampling, and Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery indicate that the high *E. coli* concentration near Chicago beaches was not a result of the Milwaukee discharge. Investigating Chicago precipitation levels, however, indicated that each spike in *E. coli* levels immediately followed a precipitation event in Chicago. The recommendation is not to go swimming within 48 hours following a rain event.

A brief videotape introducing Dr. George M. Gray, the newly appointed Assistant Administrator of EPA's ORD, was shown.

An Advanced Geospatial Approach To Develop High-Resolution Population Distribution for Night and Day

Budhendra Bhaduri, Oak Ridge National Laboratory, Oak Ridge, TN

Utilizing Census data for modeling and simulations causes challenges as a result of the Census data limitations, including temporal resolution limitations (e.g., Census data is geared toward residential and nighttime populations) and spatial resolution limitations (e.g., Census blocks often are too big).

Additionally, Census data assumes a uniform distribution of the population, which is not realistic. A gridded approach, however, assumes a more realistic nonuniform distribution of population with attributes associated with individual cells. Smart interpolation of the data ensures that there are many layers in the decision process. The LandScan model, developed by the Oak Ridge National Laboratory, is a population distribution model, database, and tool developed from Census and other spatial data using a uniform regular grid. LandScan was developed via Dasymetric Spatial Modeling and distributes the best-available Census counts to LandScan cells based on a likelihood coefficient calculated by this model. The model structure is the same everywhere, but weights and scores for each variable (e.g., slope; nighttime lights; land cover; road proximity; population data; and jail, hospital, and school locations) are tailored to each region. The footprint of urban areas is not always captured correctly as a result of the imprecise urban boundaries caused by the phenomenon of nonurban areas located inside the urban boundary and urban areas located outside of the urban boundary. To improve urban boundaries, high-resolution images are utilized to weight individual cells within an urban area relative to building type and densities for a more realistic distribution within the urban area. Additionally, many different datasets are used for LandScan, including Census block data for population, the Census Bureau's TIGER® Database for roads, NLCD for land cover/land use, National Elevation Data for slope, and many others.

Each Census block is evaluated individually. To determine the LandScan Nighttime Model, the population density of the block is compared with the number of houses in the block to determine if the data are realistic. The information is then compared to eight Census block models based on percent developed land, and additional data are analyzed (e.g., slope, land cover, road and railroad distances, area landmarks, schools, airports, etc.) to determine actual nighttime population distribution. Once the Nighttime Model has been prepared, the Daytime Model can be constructed utilizing tract-to-tract worker flow, Bureau of Labor statistics, and InfoUSA data to determine the number of workers per Census block. Again, land cover, road and railroad, airports, school, and other datasets are analyzed to help determine population distribution. Additionally, nighttime population, tract-to-tract worker flow, and school age children data are used to determine the size of the nonworking adult population. A subpopulation (approximately 20%) of the adult population is the mobile "shoppers" that are not necessarily at home and may be in nonresidential locations. Finally, stay-at-home, worker, shopper, school, and prison populations are analyzed to produce the daytime population distribution. Oak Ridge National Laboratory has been tasked by the Department of Homeland Security to use this approach to build the baseline data for daytime and nighttime populations for the entire Nation.

Validation and verification are performed to ensure that error in the model is minimized. Input data are quality assured, and model refinements account for the spatial disparity of population density. Census control totals are reconciled, the model is run with coarse data and compared to actual data, and data are compared to imagery to validate and verify the model. Inaccurate or imprecise TIGER® data are corrected when necessary. School databases and corresponding spatial locations are validated using imagery. Currently available land cover data and imagery include NLCD, GeoCover, and Coastal Change Analysis Program (C-CAP) data. Additionally, land use map data are more useful than land cover data.

Space-time visualization is extremely critical for disaster preparedness; therefore, the more data that are available, the better the models can be. It is a constant and ongoing effort to develop the models and data free of charge for the Federal government and other users throughout the world. In addition to the Daytime and Nighttime Population Models, models for lunchtime, rush hour, and special events (e.g., concerts, sports events) are being developed.

November 2, 2005, Afternoon Session

Moderator: Carmen Maso, EPA Region 5, Office of Science, Ecosystems, and Communities

Data Integration: Making Data Accessible and Useful for Regions, States, and Tribes

Steve Young, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC

Decisionmakers believe that they need more data, but this is not necessarily the case. From a historical perspective, in the past, data were scarce, and the analysis of the scarcely available data was at a premium. Time moved more slowly, the world was larger, and computers generally were for limited applications such as payroll. Over time, however, computers proliferated and became smaller and less expensive, increasing amounts of data became available, data systems proliferated, and the "elite" group of computer programmers began to break down, albeit slowly at first. Following this "renaissance," the approach to datasharing was to build a central database, provide a decision support system, generate graphics, and produce primitive user interfaces. Currently, as technology has advanced, the approach to datasharing is to build a centralized GIS; add satellite images or aerial photos; consider business intelligence, indicators and metrics, expert systems, and so forth; and improve data management, including registries and other shared resources. Datasharing was able to move from the old approach to the new approach because of increased availability of personal computers, the World Wide Web, and GIS; the development of networks, especially the Internet; the creation of the mouse and the graphical user interface; heightened user expectations; and an increased desire for demonstrated return on investment. The important idea to remember in gathering and analyzing data is to look at the big picture; ask the question, "Is it only tunneling a subset of the information, or is it giving an accurate picture of the larger world?"

Rapid remote sensing and the development of the portal concept (e.g., NOAA's Weather.gov Web Site) of datasharing are major developments in making data accessible. The keys to making emerging approaches effective are establishing Web services, service-oriented architectures, and (from GEOSS) interoperability and "system of systems" thinking. Current approaches are lacking data integration; it is necessary to go beyond simply gathering data and move toward data intelligence. Decisionmakers need intelligent data to make decisions, instead of just receiving a colossal amount of raw data. The GEOSS perspective, with an emphasis on Earth Observing Systems (EOS), recognizes that models (e.g., weather, climate, atmosphere, etc.) play a large part in the big picture feedback loop. These predictive models then are used to effect societal benefits through decision support systems. Additionally, decisionmakers need interactive models, visualizations, scenario development, "What-if?" capabilities, relevant indicators, a view of the larger picture (i.e., of life support systems such as water, oxygen, food, health), better GIS and remote sensing, better interpretive tools (e.g., imagery feature extraction and georeferencing), and intelligence. Multiple sensors of life support systems are necessary to see the larger picture, and technology has increased these capabilities by an order of magnitude as cost has continued to decrease. Ultimately, what is needed is real-time monitoring of vital Earth systems, information delivery to decisionmakers, the ready ability to assess decision outcomes, early recognition of surprises, and support for adaptive management. The adaptive management paradigm states that every action taken is considered an experiment because the outcome is not guaranteed, and, therefore, flexibility is needed to make course corrections after actions have been taken.

GEOSS and EPA

John Lyon, U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory, Environmental Science Division, Las Vegas, NV

Through strong international and national cooperation, existing national and international monitoring systems that will provide more complete, accurate, and accessible data and information to users and decisionmakers can be improved. GEOSS is an important element of national and global strategies for managing natural resources in a sustainable way. In Tokyo, Japan, April 2004, ministers, leaders, and delegates from 45 nations discussed the GEOSS implementation plan to foster societal benefits and determined that GEOSS would improve how the Earth system (i.e., its weather, climate, oceans, land, geology, natural resources, ecosystems, and natural and human-induced hazards) is perceived and understood. Such understanding is crucial to enhancing human health, safety, and welfare; alleviating human suffering, including poverty; protecting the global environment; and achieving sustainable development. EOS provides that understanding and, therefore, continual benefits toward sustainability. GEOSS will potentially improve the current framework for environmental monitoring that exists largely in support of regulatory imperatives but that does not yet comprehensively communicate the information and models needed for decisionmakers and the public to understand and address complex questions. Data management plans for policy and management decisions are a synthesis of multiple and often divergent views, including the GEOSS strategic plan, the IEOS strategic plan, U.S. policy, agency implementation, and IOOS DMAC, among others. Near-term opportunities that address current needs can be executed using existing community standards and protocols that conform to an extensible, component-based architecture that has a demonstrated use for decisionmaking.

It was determined that integrated data management, increased observations for disaster management, global land observations, integrated draught observations, sea level observation systems, and air quality monitoring are important to IEOS. The vision of the United States' contribution to GEOSS, via IEOS, is to enable a healthy public, economy, and planet through an integrated, comprehensive, and sustained Earth observation system. EPA's GEOSS tools may be found online at http://www.epa.gov/geoss/eos/epa_eos.html. Within GEOSS, the objective of GLOS is to develop the organizational infrastructure for a regional observing system node to coordinate data collection, modeling, and product development for the Great Lakes, their connecting channels, and the St. Lawrence River with a cooperation between the United States and Canada. Current progress on EOS and GEOSS can be found at http://www.earthobservations.org/ and http://iwgeo.ssc.nasa.gov/.

Land-Cover Characterization and Change Detection Using Multi-Temporal MODIS NDVI Data

Ross Lunetta, U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory, Environmental Science Division, Research Triangle Park, NC

The Normalized Difference Vegetation Index (NDVI) is the normalized ratio of the red chlorophyll absorption well (670 nm) and the Near-Infrared (NIR) foliar vegetation reflectance maximum (860 nm) and gives the relative index of standing photosynthetically active biomass (PAB). The MODIS NDVI 16-day composite product (version 4.0) is provided by NASA, free of charge, on the Internet and is useful data. MODIS multitemporal imagery has multiple resolutions. The objectives of utilizing MODIS imagery are to: (1) develop change detection methods to append (change only) the NLCD 2001 baseline land cover database on an annual basis; (2) provide continuous measures of PAB distributions to drive the next generation of landscape process models; (3) evaluate the use of MODIS multitemporal data to identify land cover change locations and patterns in near real-time; and (4) determine the utility of MODIS to classify land cover to characterize the outcome of alteration (conversion) events. The study area for the project is the major waters of the Albemarle/Pamlico Estuary. A land cover reference dataset based on color infrared digital ortho quarter quads was created that was suitable for the accuracy assessment of MODIS 250 m data products. To perform the accuracy assessment, a random sampling of 52 digital ortho quarter quads was obtained by stratifying by Bailey ecoregion; 13 quads were selected and overlaid with the cell network and dot grid. Validation indicated that the Level I agreement was quite good with agreement at a difference of 10 percent or less occurring in greater than 90 percent of the quads.

Following the verification and validation process, data were input into the grid module, and bad data were identified and eliminated by filtering pseudo hikes and drops followed by applying NDVI data flags for acceptable data. The data gaps left by this process were managed by performing a Fourier transformation of data into the frequency domain, separating out the cleaned signals, and performing an inverse Fourier transformation into the time domain to estimate the missing data points. Following this process, exploratory work with the data was performed and land features of interest were identified by end-members (groups of relatively pure spectra). It was found that greenup follows a very predictive pattern, and the NDVI was similar from year to year. For detecting change in land cover/land use, water and agricultural masks were created to reduce false positives. Total NDVI from each year were calculated from the data and compared for deviations that indicate change. Thresholds, standard deviations from the mean, are utilized for this comparison. Accuracy assessments indicated that using 2.5 standard deviations from the mean yielded the best results.

In summary, two-date change detection using established analytical methods tends to be performance limited in biologically complex ecosystems. Before extracting image end-members and performing change detection, MODIS time series data must first be filtered and cleaned. Results indicate that MODIS NDVI time series data analysis represents a substantial improvement in change detection monitoring capabilities. Potential EPA applications for MODIS NDVI multitemporal products include annual land cover change pattern products, updates to baseline land cover products, and continuous NDVI datastreams for future environmental modeling efforts. Potential collaborations could be utilized to: (1) determine the potential applications for annual change detection pattern products for regional scale assessments; (2) integrate continuous NDVI datastreams with distributed landscape process models to advance environmental monitoring and forecasting capabilities; and (3) develop land cover change desktop alarm capabilities to provide a potential real-time monitoring and regulatory support capability.

Forecasting Environmental Change

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A forecast is the best estimate from a particular method, model, or individual given a set of specific assumptions that may or may not turn out to be true. As such, it is imperative for forecasts to be associated with estimates of uncertainty so that decisionmakers have information as to the likelihood of a given forecast. Ecological forecasts offer decisionmakers estimates of ecological vulnerabilities and potential outcomes given specific natural events and/or management or policy options. Ecological forecasting is critical in understanding potential changes in ecological services before they happen and in developing strategies to offset or avoid catastrophic losses of services and provisions. Three types of ecological forecasts are vulnerability assessments based on current conditions, short-term forecasts, and long-term forecasts.

For vulnerability assessments, the Genetic Algorithm for Rule-Set Prediction (GARP) is utilized. GARP is a data-mining, inductive approach also utilized by NASA and USGS for their Invasive Species Forecasting System (http://bp.gsfc.nasa.gov/). EPA also has instituted the Regional Vulnerability Assessment (ReVA) Program, which provides indices of relative condition and vulnerability based on multiple datalayers and models for multiple environmental endpoints related to multiple stressors. Other examples of vulnerability assessment approaches include the USGS' GAP and ReGap analyses and the Nature Conservancy's vulnerability assessments. Short-term forecasts use real- or near-real-time data (onsite and/or remotely sensed) and base biophysical conditions that do not change (e.g., biophysical characterizations and ecosystem resiliency). Short-term models relate conditions and species occurrences to important drivers that change (e.g., ocean temperature, currents, etc.) and are the basis for mapping forecasts onto remotely sensed and other spatially continuous data. NOAA's monitoring of harmful algal blooms, the USGS/USFWS/NOAA bird migration monitoring, the Landscape Fire and Resource Management Planning Tools Project, crop productivity forecasts, and drought and famine forecasts in Africa are all examples of short-term forecasting programs. Long-term forecasts are scenario-based and use base biophysical conditions that do not change to create models that relate conditions and species occurrences to important drivers that do change. The goal of long-term forecasts is to develop decision tools and Web-based applications. The EPA Corvallis Laboratory's Alternative Futures Analysis Process, ReVa, and the Midwest Spatial Decision Support System Partnership are examples of long-term forecasting projects.

New projects for forecasting include the National Ecological Observatory Network (NEON; http://www.neoninc.org/) and the National Phenology Network. The NEON's mission is to identify and understand critical variations and interactions in environmental drivers that will enable forecasting the state of ecological systems for the advancement of science and the benefit of society. The NEON Observatory Implementation Model will consist of 20 nodes, each with 3 fixed and 1 mobile observing platform, representing climatic domains. The National Phenology Network is a continental-scale network that observes regionally appropriate native plant species and is designed to complement remote sensing observations. The data collected will be freely available to the research community and general public. Gaps that still need to be addressed for ecological forecasting include retaining and upgrading remote sensing platforms that measure land-surface, freshwater, and ocean conditions; improving biophysical data, compatibility among data, models and linkages among models, and *in situ* monitors; providing historical reconstruction (e.g., phylogenetics) and fixed, repeat biological data; and developing improved delivery systems to decisionmakers.

The Coastal Change Analysis Program (C-CAP): Land Cover and Change Information for the Nation's Coasts

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C-CAP, the objective of which is to improve scientific understanding of the linkages between coastal wetland habitats, adjacent uplands, and living marine resources, was conceived in the late 1980s and implemented as a NOAA program in the mid-1990s via grants and cooperative agreements. The C-CAP Effectiveness Review Panel identified 13 recommendations to make the program more useful, including the 7 following: leveraging other national efforts; focusing on applications; producing standard, consistent, timely products; minimizing duplicate efforts; partnering with the private sector; executing extensive outreach efforts; and collaborating with the USGS. The collaborative discussions with the USGS led to acceptance of the MRLC database concept. NOAA's innovative approach utilizes classification and regression tree analysis with standardized and accessible inputs and metadata tracking of procedures, all of which has led to increased credibility and usefulness of the land cover data. In addition to MRLC efforts, C-CAP also performs separate accuracy assessment and validation and has changed the classification scheme by adding subclassifications to the woody and herbaceous wetlands classifications. C-CAP has produced a digital map product line that includes land cover data for 2001, 5-year retrospective land cover data for 1996, retrospective change data (from 1996 to 2001), percent impervious surface and percent tree canopy data, and Federal Geographic Data Committee metadata. The data can be utilized to perform a very quick and simple land cover analysis summary and percent area change. C-CAP has completed baseline data for the West and Gulf Coasts (minus Florida) of the United

States and the Great Lakes Basin. The Florida coastline and the East Coast contracts are in place. C-CAP's priorities, however, changed following Hurricanes Katrina and Rita, resulting in the new priority of remapping hurricane-affected areas.

Appropriate uses of remote sensing include large-scale and regional applications (e.g., watershed, county, and state), resource inventories, population growth trends, and habitat fragmentation studies. Remote sensing should not be utilized for jurisdictional wetlands legislation (1 acre minimum mapping unit may overlook small, isolated wetlands or changes to wetlands), dock siting, parcel mapping, wetland permitting, or small-scale studies. C-CAP is attempting to provide the high-resolution data that is in demand. Available GIS tools to enhance the use of C-CAP data can be found online at http://www.csc.noaa.gov/crs/lca.

Regional Vulnerability Assessment (ReVA)

Betsy Smith, U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory, Environmental Science Division, Research Triangle Park, NC

One task of the ReVA Program is to understand how to utilize existing data and make it concise and meaningful for decisionmakers. Integrated science information is needed to meet ecosystems challenges. Prior strategies included synthesizing existing information to improve understanding of the effects of multistresses on the environment. ReVA synthesizes environmental data and model results to inform decisionmaking. Some issues that need to be managed are discontinuity of valuables, highly skewed data, imbalanced data (i.e., a large amount of terrestrial data but relatively little aquatic data), and the interdependency of variables (i.e., values and metrics are correlated). Because there may be statistical problems in putting together the data, many methods were examined to determine the sensitivity to data issues. How each integration method assessed each data issue was examined. Multidecision criteria requires multiple integration methods. ReVA is currently developing a toolkit that is accessible to states, Regions, and so forth that is completely portable and can be used on any scale. The toolkit was externally reviewed and received good reviews.

November 3, 2005, Morning Session

Moderator: John Perrecone, EPA Region 5, Office of Science, Ecosystems, and Communities

Large Area Monitoring for Pesticidal Transgenic Crops: How Spectral Imaging May Play a Role

John Glaser, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH

Of the 200 million acres of global transgenic crops, more than 50 percent are in the United States. Corn bioengineered to produce its own insecticide, *Bacillus thuringiensis* delta endotoxin (Bt corn), is viewed as an environmental asset for both human health and ecosystems because of the possible avoidance of pesticide applications; therefore, its lifetime is important to environmentally sustainable considerations. As the Federal Insecticide, Fungicide, and Rodenticide Act (commonly known as FIFRA) requires all pesticides to be registered, EPA is involved in the valuation process for Bt corn. Growers using Bt corn must have an integrated resistance management plan in place, and structured refuge, secondary pest impacts, multiple crop pest impacts, and monitoring and surveillance are the responsibility of the registrant. The existing monitoring strategy is to examine the development of resistance in insects and pests that are supposed to be controlled. Current monitoring strategy concerns are: (1) Four limited sections of corn crop are used as the proxy for the entire crop. (2) Infestations for the corn pests are expected to begin as local phenomena. (3) The question of whether or not current proxy samplings provide adequate information for resistance detection. In developing a proactive monitoring approach, four items need to be considered: (1) There must be a representative sampling of all acreage that is not physically possible to sample. (2) The current monitoring strategy provides insufficient warning of resistance development. (3) No direct molecular technique is available currently to detect resistance. (4) A comprehensive approach to reduce reporting time for resistance monitoring is needed.

Related spatial technologies are utilized to view leaf properties via a reflected light spectrum where incoming light is preferentially absorbed (reflected) depending on plant physiology. The health of the leaf, which is indicative of the health of the plant, can be determined via the light absorption pattern. Transgenic crop lanes also are visible via infrared photography. The project investigated if transgenic corn varieties could be distinguished from their nearest isolines (i.e., breeding pairs without transgenic traits) by spectral reflectance imagery and if pest infestations in corn could be identified by reflectance imagery. A Real-Time Data Acquisition Camera System-Hyperspectral, with a spectral resolution from 400-1000 nm and a spatial resolution of 0.5 m, was utilized for the project. The experimental design included a complete random block design replicated five times, two separate infestations with European Corn Borer (the first Infestation at V8-V10 growth stages), damage assessment via the Guthrie rating, and all plots imaged in a 2-week schedule. Logistic regression was used to differentiate groups of hybrids (i.e., a transgenic hybrid and its near isoline from other hybrids) with an overall accuracy of 92 percent. Overall, there was 78 percent accuracy in separating transgenic from nontransgenic corn varieties. Currently, the project is in the proof of concept stage, with the development of the analytical system and initial ground truthing completed. The project will soon be moving into the proof of principle stage with statistical testing development and data-mining. The proof of practice stage will follow with a working system for compliance and/or resistance monitoring.

LIDAR for Leak Detection

Barry Feldman, U.S. Environmental Protection Agency, Region 6, Dallas, TX

The innovation process is different in technologies that help maintain the public good of a clean environment. Private investment incentives are particularly weak, whereas the government role in promoting innovation is relatively strong. Government affects innovation, both directly and indirectly, via regulation, research funding, financial incentives (e.g., tax credits and other subsidies), and facilitation of technology transfer. One current environmental challenge is focused on fugitive emissions of hydrocarbons from industrial sources. Fugitive emissions are defined as routine leakage from valves, pumps, flanges, connectors, and so forth that aggregate to significant tonnage. These emissions can be hazardous air pollutants with direct health impacts; and can be controlled by equipment design or, more commonly, leak detection and repair programs. The vast majority of equipment does not leak; 84 percent of leaks come from 0.13 percent of equipment. Because of this trend, industry and EPA would like to find a faster, less expensive way to find leaks. Because most leaks are at higher ppm, they can be detected by remote sensing. Industrial process units have more than 10,000 different parts subject to monitoring, some of which that are classified as "hard to monitor." Second generation gas finder infrared thermal cameras, especially when combined with a telephoto lens, are extremely valuable for monitoring areas previously classified as hard to monitor.

The basic principle of LIDAR is that solar energy heats materials on the Earth's surface, which is then emitted back into the atmosphere at longer wavelengths. When this emitted energy passes through a plume, some of the energy gets absorbed at specific wavelengths. The absorption signature is the chemical identification. The next steps for utilizing LIDAR for leak detection include demonstrating reliability in field use as well as detection limits and the subjectivity of interpretation, standardizing procedures and recordkeeping, investigating the commercial availability of units, and developing alternative technologies. EPA, the American Petroleum Institute, and the American Chemistry Council are working together to develop testing procedures for detection limits and the range of chemicals that can be detected. Verification will include laboratory and field testing. Currently, only two field-ready imagers are known. The challenge will be to find additional commercially ready units. EPA's Environmental Technology Council (ETC), the purpose of which is to achieve environmental results through the application of innovative technology, has recommended approval of a project to address improved compliance through remote sensing. Obstacles to remote sensing include the need to verify the detection limits and range of chemicals the equipment can detect, and regulatory methodology needs to be changed to allow the use of remote sensing use. Future applications of remote sensing include the improvement of emissions inventories, determination of the cause of spikes in community monitoring networks, and performance of compliance inspections to check stack emissions and compliance with LIDAR.

Use of Remote Sensing To Assess Aquatic Systems

Robert Hall, U.S. Environmental Protection Agency, Region 9, San Francisco, CA

Structural stream physical habitat characterization includes measurements of stream size, gradient, channel substrate type and size, riparian vegetation cover, structure and complexity, and anthropogenic alterations. These physical characteristics strongly influence water quality and the capacity of a stream to support a diverse biological community. Habitat complexity is the distribution of various types of features providing fish concealment (e.g., large woody debris, undercut banks, overhanging vegetation, boulders, and residual pools). Hyperspectral imagery can be used to detect and map the distribution of large woody debris (i.e., greater than 15 cm diameter) and overhanging vegetation. LIDAR is used to measure large boulders greater than 1 m and also residual pool depth, size distribution, and frequency. Combining the two types of data provides a means to estimate residual pool volume, exposed mid-channel gravel and/or sand bars, reach-scale indices of slackwater volume, and channel complexity. Additionally, LIDAR data can measure quantitatively wetted width, bank slope, incised height greater than 15 cm, bankfull height, and width at bankfull stage. The power of hyperspectral imagery is that a large number of very narrow contiguous spectral bands of data can show spatial extent and allow for quantitative summary and analysis of features. This is an automated method to measure wetted width and to determine the number of hectares of riparian vegetation. Using near-infrared to determine wetted width is impacted by streambed substrate composition and size, riparian vegetation, and shadows. Riparian vegetation canopy cover is essential for moderating stream temperatures as well as providing habitat and an indicator of the potential aquatic community present. Hyperspectral imagery integrated with LIDAR data can determine vegetation type, structure, height, and distribution and also monitor invasive species.

The objective of the Advanced Monitoring Initiative is to develop a three-dimensional image of aquatic and riparian habitat of the Humboldt River, Nevada, to classify watershed morphology and invasive species. Spectral Imagery LIDAR Composite (SILC) technology was used to integrate hyperspectral digital imagery elements with LIDAR surface data. The SILC process fuses hyperspectral pixels photogrammetrically with individual X,Y,Z values. Each laser return is mathematically projected through collinearity equations onto its proper position on the frame array. By using imagery acquired simultaneously with the surface data, each surface point possesses an accurate spectral signature assigned to its location, allowing accurate classification of features using conventional remote sensing techniques. The SILC data allow urban terrain, forested terrain, agricultural lands, mountains, cliffs, ravines, and wetlands to be subjectively masked and filtered, providing vastly improved bare-earth surfaces and feature extraction. The objective of the Water Quality/Clarity project is to couple multispectral and hyperspectral remote sensing data to measurable water quality parameters with the lake's physical dynamics to develop a time series (i.e., seasonal) model of lake water quality/clarity. Methodology includes calibrating the satellite imagery with current water quality parameters (e.g., total nitrogen, phosphorus, Chl-*a,b,c*, turbidity, etc.), developing a time-series model of seasonal fluxes of each of the parameters, and ultimately, developing a three-dimensional model of the lake by combining high-resolution multibeam acoustic bathymetry and backscatter data.

In summary, quantitative structural and biological stream data acquired over a given spatial area and temporal period are fundamental information needed to determine reference conditions, stream stability, and the changing conditions of the stream channel and riparian zones over time. The need for most state and tribal bioassessment programs is to maximize the return on investment of acquiring this data. There are multiple advantages to hyperspectral and LIDAR data. The major advantage is the cost to benefit relative to high-density ground sampling assessment to cover the same land area as it increases resolution accuracy of more qualitative sampling programs and increases spatial interpolation and extrapolation of point-based ground measurements.

Round Table Discussion: Regional, State, Tribal, and Local Views

Panel Members: Ted Prescott, Illinois Environmental Protection Agency; John Esch, Michigan Department of Environmental Quality; Jeff Herter, New York State Department of State; E.J. McNaughton, Indiana Department of Environmental Management; and James Robb, Indiana Department of Environmental Management

Panel Comments

Ted Prescott stated that the State of Illinois needs remote sensing tools that can be applied to sites, the ability to apply stream characteristics to point source and nonpoint source pollution, and the use of leak detection to determine river pollutants. The Census information that illustrates population movement at various times of the day would be particularly useful. States also would benefit from available imagery being placed in a central clearinghouse/portal that each state could access. Currently, most states do not have the budget to generate their own imagery. Assistance with brownfield redevelopment also would be helpful.

John Esch stated that geologists have been utilizing geophysics for decades, and he was surprised that geophysics, a form of remote sensing, was not mentioned during the workshop. He stated that it was hard for him to visualize the application of the Great Lakes Basin information and tools to Superfund sites. Additionally, access to historical data is just as valuable as access to new data to assist with ground contamination cleanup, so that the history and cause of the ground contamination can be determined. Better elevation data are needed, and the State of Michigan is interested in statewide LIDAR coverage. There also is a great need in Michigan for thermal sensors (especially for naturally occurring methane). Although it is not an environmental application, remote sensing could be utilized for investigating the location of strategic minerals. Additionally, the State of Michigan has an immense interest in glacial geology mapping. To assess water withdrawal in Michigan, aquifers need to be characterized. Brownfield redevelopment also is an issue of concern, especially in the industrial cities of Flint, Lansing, and Detroit.

Jeff Herter explained that the New York State Division of Coastal Resources administers grants and brownfield projects. The GIS branch of the division provides mapping for the use of all branches in the division, which is currently utilizing remote sensing for land cover change analysis for Long Island, New York. The division also has completed a static nonpoint pollution project utilizing modified C-CAP data, as well as a nonpoint pollution model for Lake George, New York. An open space analysis of the south shore of Long Island with modified C-CAP data has been completed. A wetland loss analysis using aerial photography was completed for south shore marsh islands. A New York State digital orthophotography dataset is available for public download at the New York State Web Site. It is a development tool for local government decisionmakers in which to enter a storm event and pollutant and be provided with best practices for watershed management. Additionally, New York has developed the New York State GIS Clearinghouse (http://www.nysgis.state.ny.us/) in a coordinated effort with various partners, including local governments, state agencies, universities, and industry. Data in the clearinghouse is for members only. The partnership has several working groups, including a land use/land cover workgroup. The 22nd

New York State GIS Conference will be held October 23-24, 2006, in Lake Placid, New York (http://nysgisconf.esf.edu/). Additionally, he found the free data download sites mentioned in the workshop useful, as well as the mapping of invasive species via hyperspectral imagery.

E.J. McNaughton stated that the State of Indiana has flown the entire state to create a base product with a resolution of 12 inches in most areas. Some counties added additional funding to have 6-inch resolution of their areas. The photos encompass seven terabytes of information and include DEM data with 2 feet contours. The state is attempting to release the data to all interested parties, including the public, and Indiana University and Purdue University have the data available for public download on their Web sites. Infrared data with 1 m resolution will be available on the Web site by March 2006. What the state would like from EPA and other agencies is more data and a variety of sources to find data of critical importance. The 2006 Indiana GIS Conference will be held in Indianapolis, Indiana, on March 7-8, 2006 (http://www.in.gov/ingisi/conference/index.html).

James Robb stated that remote sensing information has been utilized to examine gross mitigation compliance. IKONOS satellite data was acceptable for gross mitigation but was not as useful for wetland impact assessment. The state wishes to utilize remote sensing data to identify those who do not report wetland impact. Coarser resolution imagery is useful for obvious changes, but less obvious changes also need to be investigated. It is necessary to prioritize spending for inspections, and the state would appreciate help in determining what to prioritize. Currently, the State of Indiana is trying to determine how many wetlands exist in the state and the percent increase or decrease from historical data. It would be helpful if USFWS information could be scaled down to the state level. Orthophotography and infrared band data would especially be helpful. Indiana counties currently are leading the way in GIS and have started mapping land use and examining impervious surfaces. The Indiana Department of Natural Resources is interested in advanced flood mapping. The Little Calumet River, arguably the most polluted water body in the United States, has an immense restoration project currently underway. More expertise and more opportunities to confer with remote sensing experts (e.g., at workshops such as this one) as well as stable updates and increased sharing (i.e., willingness and ability) also are needed. Knowing for what purpose data should and should not be used also is important. Historic data are needed to monitor why and how land use has changed over time. Infrared data at an increased resolution are needed for water bodies. Buffer mapping also is needed. Land use and land change data need to be standardized. Validation and ground truthing information need to be shared as well.

General Discussion

Barry Feldman of EPA Region 6 commented that EPA's ETC is creating a remote sensing database that will be as good as the information that is being contributed. He encouraged workshop participants to share their data and help build a quality database. Initially, the database will only be available within EPA because of the EPA firewall, but work on changing the firewall requirements so that the database may be shared outside EPA is underway. The hope is that it will be propagated by mid-2006.

Steve Young of EPA's Office of Environmental Information mentioned the National Environmental Information Exchange Network (http://www.exchangenetwork.net/) and its grant program. Sharing data is consistent with the goals of the grant program, which offers opportunities for states to pursue shared access for imagery.

Steve Goranson of EPA's Region 5 Office of Information Systems added that he was the Regional contact for the National Environmental Information Exchange Network grant program, and he followed the progress of Region 5 grantees. All states within Region 5 have nodes on the network. The highlight of the grant program is the geospatial information generated. His office is cooperating with the State of Wisconsin in a discovery and delivery relationship that complies with EPA's firewall by establishing an extranet so that groups outside of EPA can view Region 5 holdings and metadata, and download data.

EPA is working on ensuring that various catalogs can network with each other and are well populated; scalability is a key factor. Brenda Smith of EPA's Office of Environmental Information is the chief geographic information officer and is working on making geospatial information a one-stop program with other Federal agencies. The EPA workgroup meets regularly to discuss data needs and other issues and is very interested in keeping an open dialogue with the states. A data exchange network would open opportunities for states to inform EPA about their data needs so that grant money could be aimed toward relevant needs. Additionally, the USDA's Natural Resources Conservation Service has established an extensive Web site. Jim Wickham of NERL is slowly populating data for public use on the Web. EPA grants in this area are being promoted. The grant program is a great forum to formulate needs and make connections.

Ronell Haney of EPA Region 5 found real-time monitoring to be of interest. As it is an intensive process to rewrite real-time data (i.e., creates an increased load on the Web server), he asked if there was particular equipment that was necessary and what would be the justification for the equipment. Dr. Goranson responded that each division must prioritize internally what equipment is necessary for their requirements. Real-time data are particularly useful in emergency response (Brian Cooper of EPA Region 5 is working on a rapid assessment tools application). Mechanisms are in place to capture data that has been invested in, but a continual program to monitor water must rely on USGS servers and the main EPA server. A national meeting is taking place in Las Vegas, Nevada, during the last week of November and first part of December, and there will be a meeting session entitled "Extreme IT" that will address such issues. ORD is well aware of technology needs. Tools are available, but it is a matter of prioritization. EPA is working with other Federal agencies to address this issue.

Mike LaBatte of the Lake Traverse Reservation Tribe stated that his tribe is now utilizing GIS, and their large database has grown dramatically. As GIS Manager, he would like to update land use and land cover DEM for the 1,500 square mile, predominantly cropland reservation and asked what the best tool was for his situation, which included producing the land use/land cover data for the tribe to plan for the EPA grant and also producing the best land use/land cover data to provide tribal decisionmakers with a sufficient knowledge of their environment. Ric Lopez of EPA's NERL ESD answered that ESD maintains a Web site (http://www.epa.gov/nerlesd1) that has links to find a variety of the tools discussed at the workshop. The Analytical Tools Interface for Landscape Assessments (commonly known as ATtILA) is a tool for use in the ArcView environment to produce landscape metrics. Tools also are available to design individual-specific outputs. Western datasets from southeastern Arizona also are available on the Web site. Additionally, there are demonstrations of ESD's previous (i.e., the last 5 to 10 years) work with datasets. The Web site also contains summary data for various regions of the United States. The Landscape Ecology Branch Web Site (http://www.epa.gov/nerlesd1/land-sci/default.htm) also is very useful. Dr. Goranson added that Rick Farnsworth discussed a Midwest partnership that encouraged participation to increase the value of the toolkit, including "off the shelf" data and user models. The Web address for the partnership is http://www.epa.gov/waterspace. The partnership is working with ORD and state programs in nonpoint source run-off, total maximum daily loads, and watershed analysis. Partnerships with and data from other agencies, groups, and organizations would be helpful. Anyone interested in collaborating can contact Rich Zdanowicz of EPA Region 5. Dr. Lopez reiterated that there are many resources on the ESD Web Site, including a link to the Environmental Photographic Interpretation Center (EPIC) group in Reston, Virginia, which is a field station of the Landscape Ecology Branch of ESD and provides many beneficial data and tools for remote sensing. Dr. Young added that there also is a phenomenal reconstruction of grounds from a historical perspective. Dr. Lopez added that historic photography dating back to the 1930s also is available for EPIC, which could be accessed by visiting the on the ESD Web Site.

Mr. Prescott asked if any of the Federal agencies were able to obtain the Sanborn Fire Insurance maps in color, because they are invaluable for Superfund sites. Dr. Lopez suggested that the EPIC group might be able to provide color maps or guide him to resources that could provide this information.

Mr. Herter commented that, although datasharing in the past has not always been forthcoming, New York State has created a datasharing cooperative that has moved beyond former impediments to datasharing. At the New York State GIS Clearinghouse Web Site there is a description of the datasharing cooperative and directions on how to join. Mr. Haney stated that datasharing has different applications and, therefore, there are many different software programs necessary. He asked Mr. Herter who is responsible for converting data into a uniformly readable format in the datasharing cooperative. Mr. Herter responded that when the cooperative was formed, recommendations for the appropriate data format were made. Generally, map information data are in the tab file format. Those who send in data are responsible for ensuring that the data are in the correct format. Bert Guindon of the CCRS added that there is a lot of commercially available software for converting data to the proper format.

Mr. Esch returned the discussion to the National Environmental Information Exchange Network grant program. He commented that the program may be good for certain types of projects but not all. The Superfund Electronic Data Deliverable (EDD) process made it clear that different groups within EPA are not communicating, and different Superfund regions have different EDDs. Dr. Young responded that this was a fair criticism and that EPA is trying to improve communications. The Superfund programs have a vast amount of money and tend to be somewhat autonomous as a result. Their budget, however, has decreased, and many programs within EPA are increasing communication and collaboration. The problem has not been solved completely, but the Office of Environmental Information was created to work across programs and increase communication. Dr. Goranson added that research and development architecture needed to be created in addition to program and administrative architecture. There are an increasing number of Federal partnerships so that Federal partnering agencies can optimize efficiency. In regard to the Superfund issue, Dave Wilson, the Superfund Division Remedial Project Manager, is currently trying to convert the EDD data format to an XML format. The attempt is being made to tie things together as much as possible, including advertising software (e.g., Geode) that is being developed by the Regions.

Zenny Sadlon of EPA Region 5 Office of Information Services stated that when he first began work at EPA 5 years ago, he spent a lot of time inputting data into databases because it was not known that the information was already available. The climate has changed, and EPA is now trying to solve these problems, including a variety of collaborations with outside organizations. Starting with the belief that real problems for real people are being solved is a good beginning. The NEON may have the answers.

David Macarus adjourned the meeting at 11:58 a.m.

Attachment 1

EPA Office of Science Policy
Regional Science Workshop on Remote Sensing and
Landscape Characterization Agenda

Regional Science Workshop on Remote Sensing and Landscape Characterization

U.S. EPA Region 5
Lake Michigan Room, 12th Floor
Valdas V. Adamkus Environmental Resource Center
77 W Jackson Boulevard
Chicago, IL 60604

November 1 – 3, 2005

AGENDA

<u>Day 1: Tuesday, November 1, 2005</u>

1:00 p.m.	Welcome to the Workshop **Bharat Mathur, EPA Region 5 Deputy Regional Administrator** Introduction of the ORD/Regional Workshop Series **David Klauder, ORD/OSP**, and **Gary Foley, Director of NCER**, by video. Introduction to this Workshop: **David Macarus, Planning Committee Chair**
1:20 p.m.	Remote Sensing: How Do We Do It – What Does It Give Us – Resolution – Opportunities for Spectral Analysis – Cost of the Various Options **Ross Lunetta, ORD/NERL/ESD, Research Triangle Park, NC**
2:20 p.m.	National Land Cover Database – Historical 1992-2001 **James Wickham, ORD/NERL/ESD, Research Triangle Park, NC**
2:50 p.m.	Break
3:05 p.m.	National Wetland Inventory and Remote Sensing Applications in Wetlands Evaluation **Brian Huberty, Regional NWI Coordinator, USFWS, Ft. Snelling, MN**
3:35 p.m.	CCRS Activities in Great Lakes Landscape Characterization and Urban Energy Use Sustainability **Bert Guindon, Canada Centre for Remote Sensing, Ottawa, ON**
4:05 p.m.	Discussion and Announcements
4:30 p.m.	Adjournment

<u>Day 2: Wednesday, November 2, 2005</u>

8:30 a.m. <u>Great Lakes Challenges</u>

8:30 a.m.	Great Lakes Geographic Analysis **Ric Lopez, ORD/NERL/ESD, Las Vegas, NV**
9:00 a.m.	Great Lakes Observation System "GLOS" **Roger Gauthier, Great Lakes Commission, Ann Arbor, MI**

9:20 a.m. The Midwest Watershed Decision Support Systems Partnership – Great Lakes Update
Rick Farnsworth, Purdue University, West Lafayette, IN, and **Jon Bartholic, Michigan State University, East Lansing, MI**

9:50 a.m. "Did the May 2004 Milwaukee Sewer Overflows Affect Chicago Beaches?"
David C. Rockwell, Great Lakes National Program Office, Chicago, IL

10:10 a.m. Break

10:30 a.m. Remote Sensing for Day Versus Night Population Estimating/Uses in Emergency Response and Homeland Security
Budhendra L. Bhaduri, Oak Ridge National Laboratory, Oak Ridge, TN

11:30 a.m. Discussion and Announcements

12:00 noon Lunch

1:00 p.m. Data Integration: Making Data Accessible and Useful for Regions, States, and Tribes
Steve Young, OEI, Washington, DC

1:40 p.m. GEOSS: My Life and Times With a Global Consortium
John Lyon, ORD/NERL/ESD, Las Vegas, NV

2:10 p.m. Landscape Changes – Opportunities for Real Time Monitoring and Enforcement Follow-Up
Ross Lunetta, ORD/NERL/ESD, Research Triangle Park, NC

2:50 p.m. Break

3:10 p.m. Forecasting Environmental Change
Bruce Jones, ORD/NERL/ESD, Las Vegas, NV

3:50 p.m. NOAA C-CAP Program
John McCombs, NOAA, Charleston, SC

4:20 p.m. Regional Vulnerability Assessment (ReVA)
Betsy Smith, ORD ReVA Program Director, Research Triangle Park, NC

4:30 p.m. Adjournment

Day 3: Thursday, November 3, 2005

8:30 a.m. Crop Identification: Genetically Modified Crops/Identification of Crop Damage
John Glaser, ORD/NRMRL, Cincinnati, OH

9:00 a.m. LIDAR for Leak Detection
Barry Feldman, EPA Region 6, Dallas, TX

9:30 a.m. Quantifying Stream Attributes Using LIDAR and Hyperspectral Imagery
Robert K. Hall, U.S. EPA Region 9, San Francisco, CA

10:00 a.m. Break

10:20 a.m. Regional, State, Tribal, and local Views – Round Table
"What's in It for Me?" Are These Tools Helpful Now or in the Future?
For: Air Quality/Urban and Rural Air Pollution
Water Quality Monitoring/Aquatic Ecosystems
Contamination Sources for Recreational Waters
Pollutant Source Identification Agriculture

Open discussion with audience regarding the application and value of remote sensing for monitoring, landscape characterization, and enforcement.

12:00 noon Adjournment

Attachment 2

EPA Office of Science Policy
Regional Science Workshop on Remote Sensing and
Landscape Characterization Participants List

Regional Science Workshop on Remote Sensing and Landscape Characterization

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November 1 – 3, 2005

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Attachment 3

EPA Office of Science Policy
Regional Science Workshop on Remote Sensing and Landscape Characterization Evaluation Summary

Regional Science Workshop on Remote Sensing and Landscape Characterization

U.S. EPA Region 5
Lake Michigan Room, 12th Floor
Valdas V. Adamkus Environmental Resource Center
77 W Jackson Boulevard
Chicago, IL 60604

November 1 – 3, 2005

EVALUATION SUMMARY

EPA is one of the U.S. Federal Agencies that is promoting the multi-national Global Earth Observation System of Systems (GEOSS). When developed, this system is expected to deliver timely information on conditions of the Earth based on databases shared globally by more than 30 countries. It is expected that the availability of this global information will be valuable to assist in planning renewable and non-renewable resources and large-scale environmental changes. Regional staff remain skeptical that GEOSS can provide assistance in enforcement, pollution prevention, and sustainability initiatives. Some of the data to be used in GEOSS, however, will be derived from remote sensing technologies, many of which have application to local conditions. This workshop addressed the tools that may assist the Regions, states, and tribes in learning how to access and use remote sensing tools in landscape characterization in ways that can assist in Regional work.

The purpose of the workshop was to bring available remote sensing technology to Regional staff and illustrate how adding remote sensing to ground-based data enhances landscape characterization that guides Regional enforcement, pollution prevention, and long-term sustainability efforts.

An evaluation of the workshop was conducted to elicit information from attendees regarding the workshop organization and logistics, the information presented, and potential improvements in future workshops. A total of nine elements were developed for the evaluation form (see Appendix A). All nine elements allowed attendees to rate the sessions and elements of the meeting on a scale of 1 (poor) to 4 (excellent). A fill-in-the-blank section allowed the attendees to state the most and least informative sessions. Three open-ended questions allowed attendees to provide any other comments or suggestions for future workshops. Attendees also could provide additional comments regarding each of these questions. A summary of the evaluation findings is provided below. Results received for each evaluation question, including ratings and comments, follow the summary of findings.

Part I. Summary of Findings: Sessions

- Of the 64 meeting participants, 21 completed the evaluation questionnaire for an overall response rate of 33%
- The attendees rated their overall impression of the meeting. Of 21 respondents, 11 (52.4%) provided a rating of 3, and 10 (47.6%) provided a rating of 4, for an average rating of 3.48.
- The attendees rated the presentations. Of 21 respondents, 8 (38%) provided a rating of 3, and 13 (62%) provided a rating of 4, for an average rating of 3.62.
- The attendees rated the panel discussions. Of 9 respondents, 1 (11.1%) provided a rating of 1, 2 (22.2%) provided a rating of 3, and 6 (66.7%) provided a rating of 4, for an average rating of 3.56.

- The attendees rated the round-table discussions. Of 11 respondents, 1 (9.1%) provided a rating of 2, 3 (27.3%) provided a rating of 3, and 7 (63.6%) provided a rating of 4, for an average rating of 3.55.

Responses to Evaluation Questions

Part I. Summary of Findings: Sessions

Question 1: Overall Impression of Workshop

Rating: Number of Responses: 21
Highest Rating: 4
Lowest Rating: 3
Average Rating: 3.48

Question 2: Presentations

Rating: Number of Responses: 21
Highest Rating: 4
Lowest Rating: 3
Average Rating: 3.62

Question 3: Panel Discussions

Rating: Number of Responses: 9
Highest Rating: 4
Lowest Rating: 1
Average Rating: 3.56

Question 4: Round Table Discussion

Rating: Number of Responses: 11
Highest Rating: 4
Lowest Rating: 2
Average Rating: 3.55

Part II. Summary of Findings: Meeting Elements

- The attendees rated the workshop materials. Of 17 respondents, 1 (5.9%) provided a rating of 1, 5 (29.4%) provided a rating of 2, 9 (52.9%) provided a rating of 3, and 2 (11.8%) provided a rating of 4, for an average rating of 2.70.

- The attendees rated the registration process. Of 17 respondents, 4 (23.5%) provided a rating of 3, and 13 (76.5%) provided a rating of 4, for an average rating of 3.76.

- The attendees rated the hotel accommodations. Of 10 respondents, 10 (100%) provided a rating of 4, for an average rating of 4.00.

- The attendees rated the helpfulness of onsite support staff. Of 15 respondents, 6 (40%) provided a rating of 3, and 9 (60%) provided a rating of 4, for an average rating of 3.60.
- The attendees rated the meeting room. Of 17 respondents, 6 (35.3%) provided a rating of 3, and 11 (64.7%) provided a rating of 4, for an average rating of 3.65.

Part II. Summary of Findings: Meeting Elements

Question 1: Workshop Materials

Rating: Number of Responses: 17
Highest Rating: 4
Lowest Rating: 1
Average Rating: 2.70

Question 2: Registration Process

Rating: Number of Responses: 17
Highest Rating: 4
Lowest Rating: 3
Average Rating: 3.76

Question 3: Hotel Accommodations

Rating: Number of Responses: 10
Highest Rating: 4
Lowest Rating: N/A
Average Rating: 4.00

Question 4: Helpfulness of Onsite Support Staff

Rating: Number of Responses: 15
Highest Rating: 4
Lowest Rating: 3
Average Rating: 3.60

Question 5: Meeting Room (sound, space, lighting)

Rating: Number of Responses: 17
Highest Rating: 4
Lowest Rating: 3
Average Rating: 3.65

The most informative session was:

- Hard to say.
- Great Lakes Challenge.
- The overview by Ross Lunetta was very helpful to understanding subsequent presentations.
- All.

- Population Estimating. It helps us understand potentially effected populations over time at various sites. Also, Risk Detection—has real-time potential for inspectors. 2. Multi-spectral onto LIDAR.
- Roundtable discussion. Identified needs and potential solutions.
- 1. Ross Lunetta on QA. Eye opening on QA of Remote Sensing—I learned a lot. 2. Roger Gauthier on Great Lakes Observation System (GLOS). Content rich on GLOS—great possibilities for partnership.
- Steam Characterization. Opened wide range of opportunities and possible applications.
- All very helpful.
- Ric Lopez, Budhendra Bhaduri, and Robert Hall. [Their] presentations gave me great ideas!
- Budhendra Bhaduri; Barry Feldman because it was the most "nuts and bolts" talk; and Robert Hall's talk.
- All very good. Practical applications good.
- Dr. Bhaduri's. It illuminated the high value of the synergy of remote sensing data and census data.
- Days 1 and 3.
- Transgenic Crop Characterizations.
- Remote Sensing for Day Versus Night Population Estimating, Budhendra Bhaduri, and Quantifying Stream Attributes Using LIDAR and Hyperspectral Imagery, Robert Hall. Clear, cutting-edge technology.
- Budhendra Bhaduri—he was an excellent speaker and the information was well presented, even for someone not in the field.
- Wednesday a.m.—Great Lakes analysis, including Milwaukee. Most relevant to my work (Region 5 Water/NPDES Permits).
- Ross Lunetta's presentations.
- All sessions were good.

The least informative session was:

- None.
- Panel Discussion.
- None.
- They were all good.
- None.
- John Glaser—the agricultural component is not of use to my particular needs.
- John Glaser—Needs of Large Area Monitoring for Pesticides/Transgenic Crops. Too much jargon and technical terms, does not relate to my work.
- Some of the talks were so regional and national in scope.
- Day 2.
- Remote Sensing Overview.
- First session, Day 3—Crop Identification. All were informative in some way. However, Day 3 Crop Identification session was somewhat hard to follow—confusing graphics.
- All good.

General Comments:

What did you learn that you are most likely to take back and share with staff?

- Connections.
- I will be connecting scientists in the Office of Research and Development's Research Triangle Park Laboratory with some of the speakers.

- Great workshop—all useful information.
- The ability to track contaminants (Milwaukee-Chicago) in Lake Michigan.
- Contacts; networking.
- The diversity of remote sensing capabilities, problems with the loss of useful platforms (i.e., Landsat), census applications, and the need for a portal/access to information that many cannot afford.
- Hearing what the states and tribes need.
- That Ross Lunetta's process to derive land cover change from MODIS may serve us and that he is looking for collaboration opportunities.
- That C-CAP data was available for Great Lakes. The Barry Feldman talk we can likely use right now.
- The need to share data over a broader audience.
- The variety and depth of tools and services available, much of it free, and the quality and passion of the practitioners in this field.
- Some of the accuracy measures and other analytical and statistical data treatments. The evolving use of LIDAR.
- Real-time monitoring.
- That remote sensing can provide maps that can clearly show where problems are, and possibly with enough data, the nature of problems and changes over time. Information on EPA and other Federal Web sites can be pointed out to others.
- Datasets available for use in applications.
- I learned a lot about the various remote sensing tools.

What follow-up activities from this workshop would you recommend or like to participate in?

- Applications specific to Region 5 Tribal Environmental Staff. Making available FUNDING SOURCES for remote sensing applications and data acquisition. Suggest RTOC/GAP meetings as good starting points. See John Haughland to implement.
- Lots of ideas—who and how will the issues/needs be followed up by the appropriate people/groups?
- A series of workshops broken down by satellite, airborne, and ground-based data collection systems. What's new, what works.
- Development of interested party discussion group for the use of remote sensing approaches to EPA-related issues.
- I just want to learn and understand more about remote sensing.
- Possibly more detailed (maybe "hands on" in computer room) on specific types of remote sensing. Landscape characterization (e.g., water pollution-related for those in water programs).

What could be done to make future workshops on this topic more informative and/or productive?

- Broader audiences.
- Ask speakers to show how their "tools" address specific Region/state/local health and/or environmental problems.
- Note attendees from states, tribes, and local communities.
- Will depend upon knowledge and skills of participants. Assume little to no tribal capacity/knowledge. Offer beginning, followed by intermediate, followed by more advanced. Move toward creation of tribal users group that can share information, sources, data, cooperative ventures, etc.
- Use the needs of states/tribes to formulate *next* workshop.
- More talks on the local scare and more practical application. It would have helped to have the slide handouts before each talk to be able to take notes on each slide handout, rather than trying to quickly write notes as fast as possible.
- Maybe breakout sessions by media.

- It seems like a lot of the information was jargon-filled, and several people commented that it went over their heads. More basic information and/or a clearer mission for the workshop would have helped.
- Include all handouts, including hardcopies of slides in notebook and identified by speaker. Also provide list of related Web sites and/or other references.
- Give specifics on how data can be distributed to states.

Additional Comments:

- Request information from states and Regions to formulate meeting agenda.
- Good feedback on the forum. Have handouts available *prior* to talks.
- Some handouts hard to read—size and quality.
- Came into this with a desire to learn more about how to provide land cover/land use data for the tribe I work for. Found there are MANY ways this can be done; techniques continue to morph and advance; various types of information are already available; there is much more for us to do!!
- Great workshop—great start.
- Enjoyed it.
- It would have been nice if speakers would not race though Web sites. It was hard to get them all down. Side note: not everyone drinks coffee. Hot tea or bottled water would have been nice.
- Many slides too "busy" and with type in captions and labels hard to read. Perhaps in general, fewer and more readable slides would help.
- This workshop was a good opportunity to meet the scientists who are leading the research on remote sensing.